HHS Public Access
Author manuscript
J Neurotrauma. Author manuscript; available in PMC 2015 December 14.

Published in final edited form as:
J Neurotrauma. 2014 June 1; 31(11): 1000–1007. doi:10.1089/neu.2013.3145.

Components of Traumatic Brain Injury Severity Indices

John D. Corrigan[1], **Scott Kreider**[2], **Jeffrey Cuthbert**[2], **John Whyte**[3], **Kristen Dams-O'Connor**[4], **Mark Faul**[5], **Cynthia Harrison-Felix**[2], **Gale Whiteneck**[2], and **Christopher R. Pretz**[2]

[1]Department of Physical Medicine and Rehabilitation, Ohio State University, Columbus Ohio.

[2]Research Department, Craig Hospital, Englewood, Colorado.

[3]Moss Rehabilitation Research Institute, Albert Einstein Healthcare Network, Elkins Park, Pennsylvania.

[4]Department of Rehabilitation Medicine, Icahn School of Medicine at Mount Sinai, New York, New York.

[5]National Center for Injury Prevention and Control at the Centers for Disease Control and Prevention, Atlanta, Georgia.

Abstract

The purpose of this study was to determine whether there are underlying dimensions common among traditional traumatic brain injury (TBI) severity indices and, if so, the extent to which they are interchangeable when predicting short-term outcomes. This study had an observational design, and took place in United States trauma centers reporting to the National Trauma Data Bank (NTDB). The sample consisted of 77,470 unweighted adult cases reported to the NTDB from 2007 to 2010, with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) TBI codes. There were no interventions. Severity indices used were the Emergency Department Glasgow Coma Scale (GCS) Total score and each of the subscales for eye opening (four levels), verbal response (five levels), and motor response (six levels); the worst Abbreviated Injury Scale (AIS) severity score for the head (six levels); and the worst Barell index type (three categories). Prediction models were computed for acute care length of stay (days), intensive care unit length of stay (days), hospital discharge status (alive or dead), and, if alive, discharge disposition (home versus institutional). Multiple correspondence analysis (MCA) indicated a two dimensional relationship among items of severity indexes. The primary dimension reflected overall injury severity. The second dimension seemed to capture volitional behavior without the capability for cogent responding. Together, they defined two vectors around which most of the items clustered. A scale that took advantage of the order of items along these vectors proved to be the most consistent index for predicting short-term health outcomes. MCA provided useful insight into the relationships among components of traditional TBI severity indices. The two vector

Address correspondence to: John D. Corrigan, PhD, Department of Physical Medicine and Rehabilitation, Ohio State University, 480 Medical Center Drive, Columbus, OH 43210, corrigan.1@osu.edu.

Author Disclosure Statement
No competing financial interests exist.

pattern may reflect the impact of injury on different cortical and subcortical networks. Results are discussed in terms of score substitution and the ability to impute missing values.

Keywords

AIS; Barell matrix; craniocerebral trauma; GCS; MCA; TBI

Introduction

A NUMBER OF METHODS for capturing the severity of a traumatic brain injury (TBI) have been developed, each with different purposes, and each relying upon different aspects of a patient's function or observable structural properties of the affected brain. The Glasgow Coma Scale (GCS)[1] is the most widely referenced in published literature, and likely is the most widely used clinically, because of its contribution to establishing and monitoring a patient's status during the early phase of recovery. GCS relies on observable functions that reflect the integrity of the reticular activating system as well as midbrain and cortical interaction. Several other metrics of injury severity that rely on observable functions use time from injury to a sentinel event to classify injury severity, including time to follow commands (TFC), length of loss of consciousness (LOC) and length of post-traumatic amnesia (PTA). Previous studies have found that functional indices vary in their predictive capability depending upon the outcome of interest (survival,[2] hospital discharge disposition,[3] function upon admission to rehabilitation,[4,5] and 6 month global outcome).[6] Whereas indices based on sentinel events reflecting functional recovery often predict particular outcomes better than the GCS, the GCS score is usually a close contender. Because the alternative measures of brain function provide only a single indicator of time to the event of interest, they do not have the clinical utility of the GCS, which allows hour-to-hour or day-to-day monitoring of patient status. Moreover, duration of unconsciousness or PTA can only be calculated once commands are followed or amnesia resolves, respectively, making them less useful for early prediction.

All functional methods are confounded when the patient is intentionally sedated to optimize clinical management. The GCS has additional complications because of the inability to ascertain all three subscales in certain clinical conditions (e.g., best verbal response cannot be ascertained if the patient is intubated, intoxicated, or demonstrating expressive aphasia; best motor response cannot be ascertained if the patient has receptive aphasia). These latter challenges have led to proposals for simplified and/or single subscale classification.[7] The Motor scale alone,[2,8] or the Motor scale in conjunction with pupillary response,[9] Verbal subscale,[10] or other simplifications have been found to be satisfactory substitutes.[11]

The GCS Total score is calculated by a simple addition of the three subscale scores. As a result, the same total score can result from more than one combination of subscale scores (e.g., Motor 4, Eye 3, and Verbal 3 equal 10, as do Motor 3, Eye 4, and Verbal 3). Given the that the total score is used to classify overall TBI severity (i.e., mild = 13–15, moderate = 9–12, severe = 3–8), the same subscale score can be associated with more than one category of severity depending upon the other two scores (e.g., Motor 5, Eye 3, and Verbal 4 equal 12, which indicates a moderate TBI, whereas Motor 5, Eye 4, and Verbal 4 equal 13 which indicates a mild TBI). Although the utility of subscales have been evaluated from a practical perspective, it is interesting that the assumptions underlying the combination of GCS subscales into the total score have received scant attention.

An alternate approach to assessing brain function is to examine structural or anatomical injury to the brain. The Abbreviated Injury Score (AIS)[12,13] and the classification of injury and poisoning sections of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) are the primary methods for classifying injury in general, and each includes portions designed to capture TBI severity. The AIS captures structural and functional damage in the "pre-dot" codes, and severity of the injury is denoted in the "post-dot" code that can range from 1(minor) to 6 (unsurvivable).[13,14] ICD-9-CM categories for injury to the brain describe structural aspects, although function is integrated in its incorporation of length of LOC as a modifier.[15] The Barell matrix was developed to characterize injuries based on ICD codes.[16] There are three Barell types associated with TBI that combine both structural information and function as reflected in length of LOC. Other structural approaches to characterizing TBI severity have included classification of pupillary response[17] and use of imaging results to stage injury severity, as is done with the Marshall classification score.[18]

Whereas many studies have looked at the relative effectiveness of different severity indices for prediction of outcome, there has been only limited investigation of the actual correspondence of classifications made by different indices. Conventions have been adopted without supporting research. For example, the Department of Defense, Veterans Administration, and Centers for Disease Control and Prevention scheme for classifying mild, moderate, or severe TBI uses the worst score when multiple indices are available.[19] There is little research on the effectiveness of this convention for the prediction of outcomes. Cuthbert and colleagues examined how prediction of acute hospital discharge disposition changed based on the severity classification from the GCS and AIS, and length of LOC.[3] They concluded that no one indicator differed significantly from the others; however, when more than one index indicated that a TBI was at least moderate or severe, those patients were less likely to be discharged home than those classified as having moderate or severe TBI based on only one index. Results such as Cuthbert et al.'s[3] may be the result of measurement reliability, or they may suggest multidimensional TBI severity that is not captured by single indicators.

The current study sought to examine the dimensionality of TBI severity as reflected in items that comprise TBI severity indicators. The large sample size of the National Trauma Data Bank (NTDB) afforded the opportunity to examine cases that have complete data for several TBI injury severity indices: the GCS, AIS severity score for the head, and the Barell matrix classification. We sought to determine whether individual components of these severity indicators fell along a single dimension (i.e., a clustering relationship), or if they classified TBI in multidimensional space. Results of this analysis may allow a more empirical basis for conventions adopted for classification, as well as imputation or substitution of missing values for research purposes. Findings also may provide insight into how severity indices can enhance ambulatory transport decisions and possibly enhance hospital treatment decisions.

Methods

Population

The sample was derived from over 143,697 unweighted cases reported to the NTDB from 2007 to 2010, inclusive, who 1) had an ICD-9-CM diagnosis of TBI, (800.0–801.9, 803.0–804.9, 850.0–854.1, and 959.01),[20] 2) were ≥ 18 years of age, 3) were not transferred in from another hospital, and 4) did not die in the Emergency Department (ED). As shown in Table 1, these cases were then further reduced so that the final sample would be composed of cases with no missing data for any of the severity indices or dependent variables. The final sample was composed of 77,470 cases. Demographic characteristics of the sample were calculated using means for continuous variables and proportions for categorical and ordinal variables.

Severity indices

The NTDB includes data for three traditional methods of capturing TBI severity: the Glasgow Coma Scale (GCS) Score[1] at ED admission, worst Abbreviated Injury Score (AIS) for the head as calculated by the ICDMAP algorithm,[21] and the worst Barell categorization of TBI injury.[16] The items that comprise these indices and information about their derivation are shown in Table 2. Additional information can be found in the NTDB data manual.[22]

Dependent variables

The NTDB includes data on intensive care unit (ICU) length of stay (in days), acute hospital length of stay (in days), whether the patient had died at discharge (a dichotomous variable), and whether the patient was discharged to home (with or without a home health aide) or to one of several possible types of healthcare facilities. For modeling discharge location, only those discharged alive were included in a dichotomous variable indicating whether they were discharged to home. Additional information on how these variables were captured can be found in the NTDB data manual.[22]

Statistical analysis

A two step analytic process was used. In the first, multiple correspondence analysis (MCA)[23] was conducted to investigate novel relationships between the factors that comprise each of the three measures of TBI severity in an attempt to elucidate dimensions of TBI severity. MCA produces a graphical representation of each factor in single or multidimensional space. From these representations, new dimensions of injury severity can be assessed by evaluating the location of each of the factors within the dimensional space. Factors that grouped together, referred to as clusters, were those that were positively associated with each other, whereas those that were far apart were negatively associated with each other. Examining the composition of each cluster could then be used to describe dimensions of TBI severity. In a second step, regression analyses were employed to assess the utility of the newly identified severity dimensions for prediction of the length of acute and ICU stays in days, whether the patient remained alive, and discharge location, and compare these results to those computed using the pre-existing measures of TBI severity. All analyses were performed using SAS 9.3.

MCA—MCA was performed on dichotomous variables constructed to capture each level of the three GCS subscales (Motor = six levels, Verbal = five levels, Eye Opening = four levels), six levels of the worst AIS for the head, and the three types of TBI in the Barell matrix. Dichotomous variables were incorporated in the Z matrix, which contained one row for each subject in the analysis and one column for each category of each of the variables under study. This matrix differs from typical coding used in regression analysis, in which one of the levels of the dummy variable is omitted to allow contrasts to be estimated. The columns of this final matrix are not independent, which is allowed by MCA because it does not depend upon having independent columns of variables. The MCA included a total of 24 categorical components and was computed using a Greenacre adjustment[23] to improve categorical variable fit. Greenacre adjusted inertias describe the frequency of values within a single dimension that can be used to explain data variability.

Regression modeling—To compare predictive capability of traditional measures and newly identified dimensions of TBI severity, a series of regression models were computed for each of four dependent variables. All models included age and gender, then one of the TBI severity indicators. For models predicting continuous variables, general linear models were used to assess predictive capability by evaluating the computed Akaike information criterion (AIC) and R^2 of each model. For models with dichotomous dependent variables, the predictive capabilities of logistic regressions were evaluated using the AIC, Schwartz criterion (SC), and c statistic.

Results

The two dimensional MCA solution is shown in Figure 1. The Greenacre adjusted inertias for dimensions 1 and 2 equaled 71.43% and 9.97%, respectively. The two dimensions provided the majority (81.39%) of the total possible variability explained by the progressive entry of multiple dimensions (86.91%). MCA locates all indicators in Euclidean space; the first two dimensions of the current analysis are plotted in Figure 1. The circles show groups of at least three indices that are generally equidistant from the origin (0,0), falling in the same direction. The lowest of the GCS subscale scores and AIS 5 and 6 demark the most severe injuries. The highest of these subscale scores, along with the least severe Barell types and AIS levels, form a cluster in the least severe range. The cluster with the highest dimension 2 scores contained items that reflected a resumption of volitional behavior (e.g., able to make a focal response to pain) but lack of a cogent response to external cues (e.g., being confused, not following commands).

Positions along dimension 1 largely followed the rank order of the severity of indices within a scale, thus confirming that it represented a primary severity dimension. Dimension 2 captured the extent to which there was volitional behavior without cogent processing of external stimuli. Visual inspection of the MCA results suggested two vectors defined by the two dimensional space that connected the clusters of similar indicators. As is shown in Figure 2, many indicators fell along a line connecting the cluster of AIS 1, AIS 2, and Barell

2 to Eye 2 in the cluster at the middle of the space. An even tighter configuration was evident in indicators that fell along a line from Eye 2 to the cluster on the right that included AIS 6. The vector from the lower left quadrant to the upper right was labeled the “cogency” vector, as movement along it seemed to denote more or less ability to respond to meaningful stimuli. The vector going from the upper right to lower right quadrant was labeled the “volition” vector, as it seemed to denote the ability of the person to be aroused and respond to internal stimuli. The ordering of indicators along the two vectors suggested somewhat novel relationships between indicators from different scales. The most severe injuries are marked by impaired volition, with cogency essentially capped until minimal volition is established. Once established, greater cogency can be observed. To capture this ordering, a new scale, called volition + cogency (V + C), was composed as defined in Table 3. V + C was designed to use the minimum number of indices to capture the order of indicators falling along the two vectors.

Table 4 shows the cross-tabulation of V + C by GCS Total score. Given the role of GCS Motor and GCS Eye opening to the definition of V + C, it is not surprising that there was high correspondence. Still, Table 4 also demonstrates that there are differences between the two measures at every level. Although neither the GCS nor the V + C show an even distribution across items, the V + C appears to have a higher ceiling at the good functioning end of the continuum.

The second step of data analysis tested the ability of both the traditional indices and those suggested by the MCA to predict short-term outcomes. In addition to the traditional rank versions of GCS Total, GCS Motor + Eye, AIS, and Barell type, ranked scores for Volition, Cogency, and V + C were also tested. Additionally, an interval scale was created by converting each rank indicator into an interval scale using item values from dimension 1 of the MCA. The dimension 1 score for GCS Total was created by adding the dimension 1 scores for each of the three GCS subscales. Table 5 shows the results for models predicting the four short-term outcomes. Models for each indicator are listed from smallest to the largest AIC value. Although the ordering for other statistics generally followed the same order as AIC, the designated shaded areas show results for other statistics that are not in order.

Comparisons of the range of values for each dependent variable indicate that some severity indices are clearly superior to others for prediction of short-term outcomes. The scales based on the two dimensional vectors, whether only the cogency score or the entire V + C, were slightly superior to GCS Total score in all but the prediction of being discharged alive. Of GCS subscale scores, GCS Verbal was the next most useful predictor, performing better than GCS Motor, GCS Eye, or GCS Eye + Motor. Use of the interval scale from dimension 1 of the MCA did not improve prediction for most indices.

Discussion

The NTDB was utilized to examine inter-relationships among components of several traditional TBI severity indices. MCA revealed a primary dimension that was interpreted as representing functional severity of TBI. A second dimension was also observed for which an obvious clinical interpretation was not evident. However, the two dimensional space created by the MCA results revealed two vectors along which indices were closely clustered. The first vector was interpreted to represent levels of volition, as items increased from unresponsiveness to a state of arousal that allowed localization of painful stimuli. The second vector was interpreted as representing cogency of response to external stimuli as it progressed from localizing painful stimuli to appropriate response to external stimuli. A new scale suggested by the two dimensions was created from items of the AIS, GCS Motor, and GCS Eye by ordering them based on how they fell along the two vectors. The GCS Total score was the best predictor in three of the four regression models; but the newly created V + C scale was the most consistent when predicting short-term outcomes.

Results of MCA provide some insight into the characterization of TBI severity. Regardless whether we have optimally labeled the two vectors, their presence suggests that TBI severity is not one dimensional. The two underlying vectors may represent different cortical systems affected by trauma, for example, the reticular activating system allowing arousal, and midbrain to cortical connections allowing perception and interpretation of environmental cues. However, the latter is dependent upon the former (arousal is a necessary but not sufficient condition for cogent responding); therefore, any scale that captures both will best characterize the full range of TBI severity.

The pattern of results in Figures 1 and 2 also suggests why characterization of TBIs as mild, moderate, or severe based on the GCS total score may be so effective; it grossly approximates the two vector severity score. A person whose GCS scores fall on the Volition vector will score in the severe range (i.e., from Motor 1 + Eye 1 + Verbal 1 = 3 to Motor 4 + Eye 2 + Verbal 2 = 8). Moderate TBI using the GCS Total score would result from one additional point earned for either Verbal or Motor function (i.e., GCS = 9) through gaining the next-to-highest score on all three subscales (GCS = 12). By earning the best score on any of the subscales, the GCS score reaches the mild TBI range. Therefore, whereas theoretically the combination of GCS subscales into the total could arise from any combination of scores, results of the MCA suggest that only specific combinations are likely. These observations could be used to create algorithms for data entry error-checking of GCS subscales scores. Previous literature has provided support for this approach; for example, the Simplified Motor Score [24] essentially uses the Motor score to establish mild, moderate, or severe TBI.

The results from regression analyses predicting short-term outcomes provided a very substantial endorsement of the utility of the GCS Total score. The GCS Motor score provides gradations of severity as a person moves from unresponsiveness to localizing pain. The GCS Verbal and GCS Eye Opening scores start at unresponsiveness, but are more adept than the Motor score at capturing gradations as patients move from volition to cogent interpretation of their environment. Despite these gradations, the Motor, Eye Opening, and Motor + Eye Opening scores demonstrate diminished effectiveness in predicting short-term outcomes as compared with the total score, suggesting that without the Verbal subscale, the utility of the GCS for use as a predictor may be diminished. A very pragmatic result of the current study is the suggestion that the V + C scale is an alternative to the GCS Total in instances in which the Verbal subscale is unavailable but the worst AIS severity for the head is available; however, this substitution may only be practical for research studies.

The current study also may provide some suggestions for using severity indices in clinical management. More effective pre-hospital severity assessments may lead to better transport decisions, to ensure optimal patient treatment and lead to a reduction in the overall cost of the health care system through more effective trauma triage.[25] Emergency medical service personnel use the physiological GCS Total score of < 14 in the Field Triage guideline to determine if a patient needs the services of a trauma center.[26] If the Verbal subscale is not available because the patient is intubated, either a Motor or Eye Opening score below the maximum for the respective subscale would suggest a very high likelihood that the GCS Total would be < 14 if the Verbal subscale scores were testable.

Additionally, these findings may have implications for advances in automobile telematics. If an automobile is equipped with telematics, communication between the automobile occupant and the telematics service provider operator is possible. The ability to follow a simple instruction, such as pushing one of the buttons on the steering wheel or console, mimics the GCS Motor ability to follow commands. When combined with an assessment of the occupant's best verbal response, it may be possible to infer the severity of TBI (e.g., unresponsiveness would suggest a GCS Total score from 3 to 7; incomprehensible or inappropriate verbal expression and the inability to follow a command would suggest a GCS Total score from 8 to 11; confused speech and the inability to follow a command would suggest a GCS Total score from 11 to 12; whereas cogent verbal responding or the ability to follow a command would suggest a GCS Total score from 13 to 15). Potential benefits of a rapid TBI assessment include more precise trauma triage and rapid trauma team activation prior to hospital arrival following an automobile crash. Further research is still needed to explore the potential benefits of applying this study's findings to the telematics systems currently available in most newly manufactured automobiles.

There are some limitations for interpretation of the results from the current study. First, we only looked at the utility of predicting short-term outcomes; long-term outcomes may show different results for the utility of the various severity indices. Commonly used injury severity indices tend to have poor predictive power for long-term outcomes (particularly when taken soon after the injury), and multidimensional indices may offer improvements over traditional measures.[2,27,28] Second, all cases used in this analysis had complete data. There may be systematic differences between cases with complete data and those without, especially that given clinical procedures, such as chemical paralysis or intubation, result in missing data. We also removed cases from facilities with < 80% completion of the AIS Severity Index. This criterion likely selected against cases in hospitals that see fewer trauma procedures or that do not have systematic protocols for injury documentation. Such facilities may see a different clinical population than the hospitals we included.

Conclusion

This research utilizes the physiological data in the NTDB to compare the effectiveness of TBI severity scales, and provides helpful information to other researchers and to EMS personnel involved in trauma triage. The GCS Verbal subscale was a slightly better predictor of overall outcome than the GCS Motor score. However, this work reaffirms the utility of the GCS Total score and suggests that a new V + C scale shows promise in successfully predicting short-term health outcomes. One encouraging application of these findings is the possibility of better quality pre-hospital transport destination decisions once these findings are integrated and engineered into automobile telematics.

Acknowledgment

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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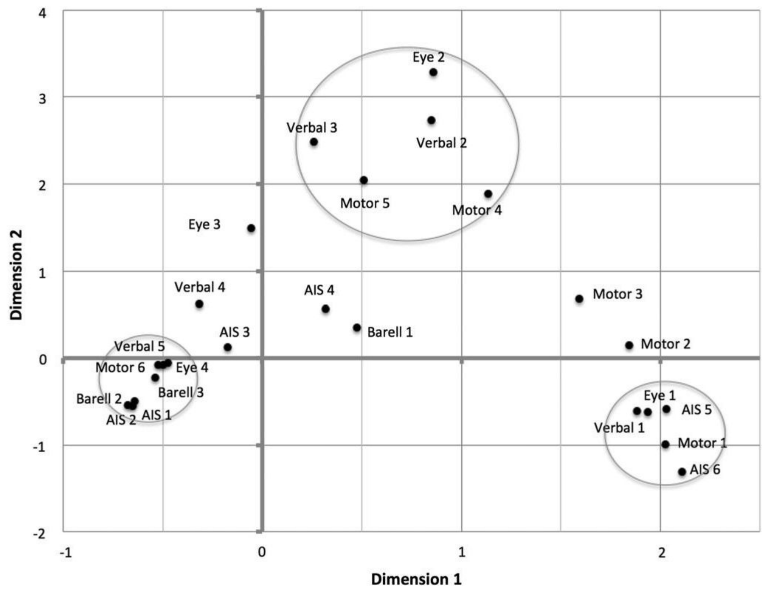

FIG. 1.
Results of multiple correspondence analysis.

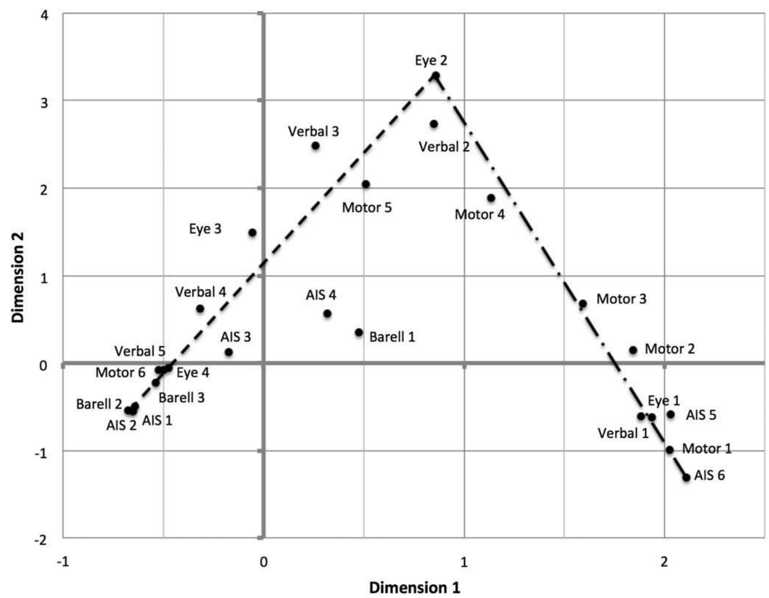

FIG. 2.

Proposed Volition + Cogency two dimensional scale. - - - - -Cogency; —•—• Volition

Table 1

Sample Definition

Sample definition	*Remaining* n
Available population (*unweighted*) 2007 to 2010, with ICD-9-CM TBI codes, ≥ 18 years of age, who were not transferred in and did not die in the ED.	143,697
Removing cases from facilities with < 80% Severity Index completion	126,006
Removing cases with missing GCS Eye	119,501
Removing cases with missing GCS Motor	119,370
Removing cases with missing GCS Verbal	119,236
Removing cases with missing GCS Total	119,236
Removing cases with missing AIS of the head	94,162
Removing cases with missing maximum Barell matrix	93,467
Removing cases with missing gender	92,731
Removing cases with missing race	87,957
Removing cases with LOS days < 1	87,927
Removing cases with missing ICU days	81,121
Removing cases with unknown dead/alive status	77,470
Removing cases with unknown hospital discharge status	77,470

AIS, Abbreviated Injury Score; ED, Emergency Department; GCS, Glasgow Coma Scale; ICD-9-CM, International Classification of Diseases, Ninth Edition, Clinical Modification; LOS, length of stay; TBI, traumatic brain injury.

Table 2

Levels of Traditional Severity Indices

Abbreviated Injury Score for the Head derived from ICDMAP (categories are mutually exclusive)	
AIS 1	Minor
AIS 2	Moderate
AIS 3	Serious
AIS 4	Severe
AIS 5	Critical
AIS 6	Unsurvivable

Glasgow Coma Scale: lowest recorded by EMS or in the ED (mutually exclusive within subscales)	
Motor 1	Makes no movements
Motor 2	Extension to painful stimuli
Motor 3	Abnormal flexion to painful stimuli
Motor 4	Flexion/Withdrawal to painful stimuli
Motor 5	Localizes painful stimuli
Motor 6	Obeys commands
Eye 1	Does not open eyes
Eye 2	Opens eyes in response to painful stimuli
Eye 3	Opens eyes in response to voice
Eye 4	Opens eyes spontaneously
Verbal 1	Makes no sounds
Verbal 2	Makes incomprehensible sounds
Verbal 3	Utters inappropriate words
Verbal 4	Confused, disoriented
Verbal 5	Oriented, converses normally

Barell types based on all entered ICD-9-CM Codes (only a patient's worst type was used)	
Barell 1	Type 1 TBI: skull fracture or concussion with > 1h loss of consciousness OR any cerebral abnormality including open head injury OR shaken baby syndrome
Barell 2	Type 2 TBI: skull fracture or concussion with up to 1 h loss of consciousness, including loss of consciousness unspecified
Barell 3	Type 3 TBI: skull fracture but no loss of consciousness

AIS, Abbreviated Injury Score; ICD-9-CM, International Classification of Diseases, Ninth Edition, Clinical Modification; ICDMAP, International Classification of Diseases MAP; EMS, emergency medical services; ED, emergency department; TBI, traumatic brain injury.

Table 3

Levels of a Two Dimensional Scale Derived from Multiple Correspondence Analysis of TBI Severity Indices

AIS	*GCS Motor*	*GCS Eyes*	*Volition* [a]	*Cogency* [b]	*V + C*
6	Any	Any	0	1	1
≠6	1	Any	1	1	2
≠6	2	Any	2	1	3
≠6	3	Any	3	1	4
≠6	4	Any	4	1	5
≠6	5	1,2	5	1	6
≠6	5	3,4	5	2	7
≠6	6	1,2,3	5	3	8
3,4, or 5	6	4	5	4	9
1,2	6	4	5	5	10

[a] Volition denotes the ability to localize internal stimuli.

[b] Cogency denotes the ability to respond to meaningful stimuli.

AIS, Abbreviated Injury Score; GCS, Glasgow Coma Scale; V + C= volition plus cogency.

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Table 4

GCS Total by Volition + Cogency Score

GCS Total	*Volition + Cogency*											
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Total*	
3	41	9678	0	0	0	0	0	0	0	0	9719	22.5%
4	2	152	360	0	0	0	0	0	0	0	514	1.2%
5	0	54	38	374	0	0	0	0	0	0	466	1.1%
6	4	110	37	101	759	0	0	0	0	0	1011	2.3%
7	0	44	26	36	375	601	0	0	0	0	1082	2.5%
8	0	6	17	67	271	437	0	62	0	0	860	2.0%
9	0	17	8	37	297	232	84	26	0	0	701	1.6%
10	1	10	6	10	204	154	368	100	0	0	853	2.0%
11	0	0	3	11	157	116	389	120	130	29	955	2.2%
12	0	0	0	8	90	4	659	182	122	23	1088	2.5%
13	0	0	0	0	19	0	766	967	231	53	2036	4.7%
14	1	0	0	0	0	0	138	623	4346	1017	6125	14.2%
15	6	0	0	0	0	0	0	0	13,832	3916	17,754	41.1%
Total	55	10,071	495	644	2172	1544	2404	2080	18,661	5038	43,164	
	0.1%	23.3%	1.1%	1.5%	5.0%	3.6%	5.6%	4.8%	43.2%	11.7%		

GCS, Glasgow Coma Scale.

Table 5

Prediction of Short-term Outcomes

ICU days *index*	*AIC*	R^2	*Discharged alive* *index*	*AIC*	*SC*	*c*
Cogency	370930	0.1404	Max AIS	30496	30597.353	*0.873*
V + C	371455	0.1345	Dimension 1-Max AIS	30540	30604.817	*0.873*
GCS total	371699	0.1318	GCS total	31456	31520.430	0.886
Dimension 1-GCS total	371827	0.1303	V + C	31586	31651.047	0.886
GCS verbal	371836	0.1302	GCS eye + motor	31860	31924.746	0.882
Dimension 1-GCS eye + motor	371855	0.1300	Dimension 1-V + C	31867	*31888.141*	0.881
Dimension 1-GCS verbal	372101	0.1273	Dimension 1-GCS total	31883	31948.214	0.881
Dimension 1-V + C	372175	0.1264	Dimension 1-GCS eye + motor	31909	31973.760	0.881
Dimension 1-GCS motor	372309	0.1249	Dimension 1-GCS motor	31929	31994.271	*0.880*
GCS eye + motor	372404	0.1238	Dimension 1-GCS verbal	32305	32370.279	0.879
GCS eye	372466	0.1231	GCS verbal	32309	32373.406	*0.876*
Dimension 1-GCS eye	372646	0.1211	GCS motor	32351	32416.138	0.878
GCS motor	373272	0.1140	Cogency	32651	32715.405	0.874
Volition	374554	0.0992	Dimension 1-GCS eye	32746	32810.376	0.872
Max AIS	375604	0.0870	GCS eye	32777	32841.379	0.870
Dimension 1-Max AIS	376170	0.0802	Volition	32967	33031.796	0.868
Max Barell	377437	0.0651	Max Barell	39574	39648.264	0.743
None	382360	0.0037	None	44436	44491.525	0.604

LOS days *index*	*AIC*	R^2	*Discharged home (if alive)* *index*	*AIC*	*SC*	*c*
Cogency	460838	0.1045	Cogency	70947	71010.798	0.767
V + C	461400	0.0980	V + C	71247	71311.008	0.765
GCS total	461601	0.0956	GCS verbal	71312	71376.051	0.764
GCS verbal	461647	0.0951	GCS total	71373	71437.519	0.763
Dimension 1-GCS total	461697	0.0944	Dimension 1-GCS total	71592	71656.277	0.761
Dimension 1-GCS eye + motor	461704	0.0944	Dimension 1-GCS eye + motor	71661	71725.205	0.760
Dimension 1-V + C	461894	0.0922	Dimension 1-GCS verbal	71790	*71726.183*	*0.760*
Dimension 1-GCS verbal	461909	0.0920	Dimension 1-V + C	71826	71890.604	0.758
Dimension 1-GCS motor	461998	0.0910	Dimension 1-GCS motor	71916	71980.538	0.757
GCS eye	462082	0.0900	GCS eye + motor	72042	72106.012	0.756
GCS eye + motor	462114	0.0896	GCS eye	72262	72326.135	0.754
Dimension 1-GCS eye	462215	0.0884	Dimension 1-GCS eye	72422	72486.167	0.752
GCS motor	462758	0.0820	GCS motor	72631	72695.471	0.750
Volition	463725	0.0705	Max AIS	73120	73220.554	0.743
Max AIS	464481	0.0615	Dimension 1-Max AIS	73162	73226.506	0.742
Dimension 1-Max AIS	465310	0.0513	Volition	73577	73641.492	0.738
Max Barell	465625	0.0474	Max Barell	75429	75502.069	0.719
None	469105	0.0036	None	79044	79098.669	0.662

Statistics in *italics* are not in descending order of greatest predictive ability.

AIC, Akaike Information Criterion ; AIS, Abbreviated Injury Score; GCS, Glasgow Coma Scale; Max, maximum; SC, Schwartz Criterion; V + C, Volition plus Cogency.